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(54) Profile measuring instrument

(57) An optical profile measuring instrument for inspecting surfaces of specimens to be tested includes a polychromatic light source 21 having a slit shaped aperture and a collimator lens 23. The collimated beam is dispersed longitudinally by a lens 27A and focused into a series of focal points  $F_1$  to  $F_n$  by a lens 27B. Each focus point is associated with a particular wavelength. Light reflected from a specimen 29 is deflected by a separator 25 onto device 31 which angularly disperses the light and focuses it onto an array of photodiodes 33 connected to a detection circuit 35. The diodes 33 are sequentially scanned to provide an output signal whose maximum value corresponds to the position of the surface of specimen 29.

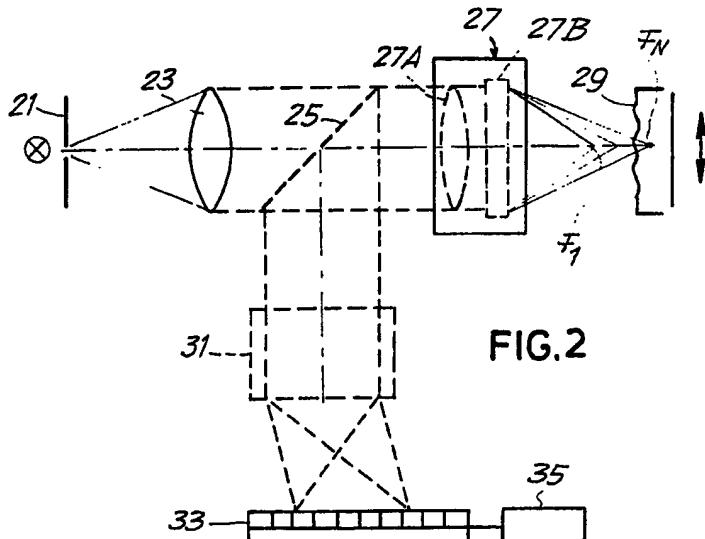
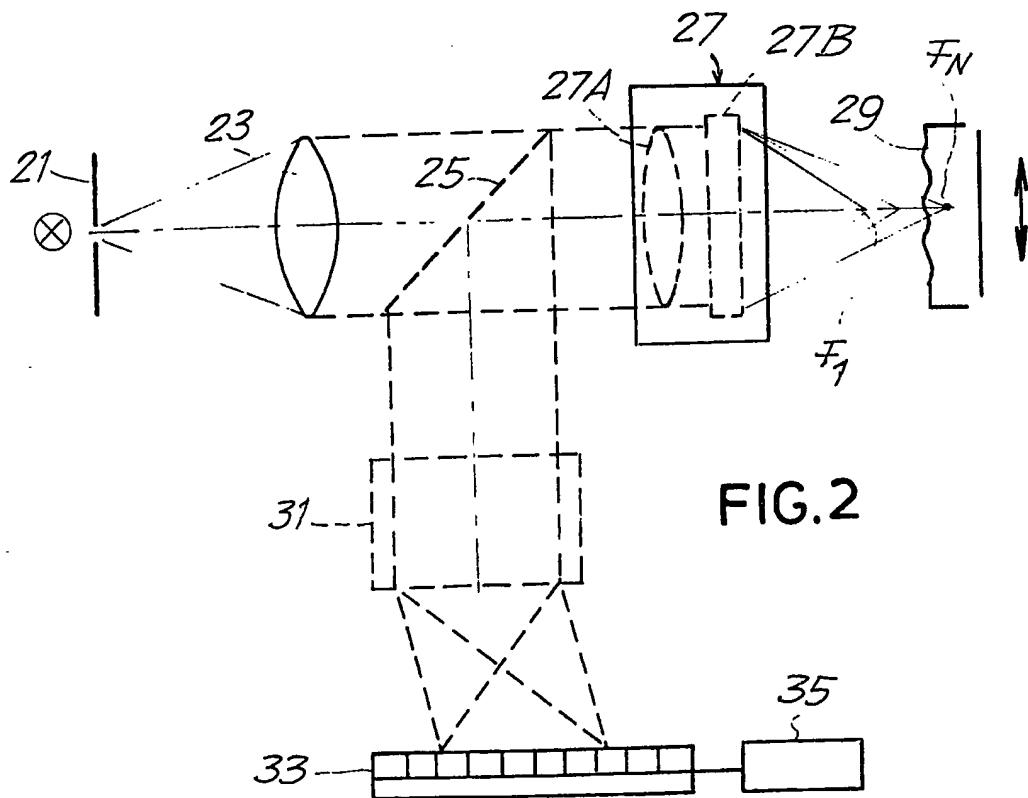
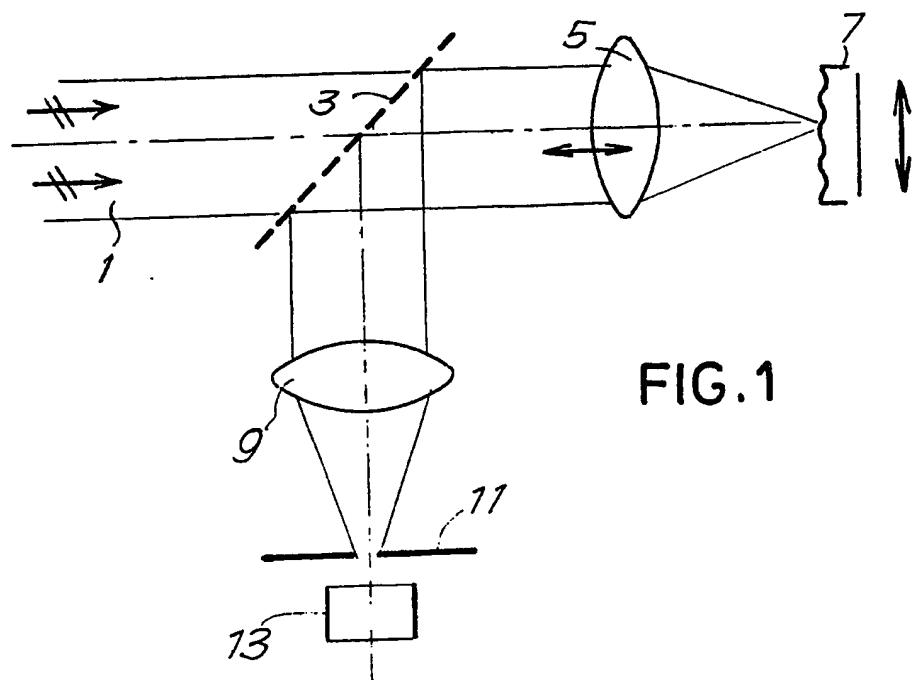


FIG.2

GB 2 144 537 A



## SPECIFICATION

## Profile measuring instrument

5 This invention relates to an optical profile measuring instrument for inspecting the surfaces of specimens to be tested.

Mechanical surfaces are characterized by their finish in terms of roughness (microfinish)

10 as well as by their macroscopic condition. Many of the operating characteristics of the final component are due to this finish. The microfinish may be expressed in terms of the values of a number of parameters such as  $R_s$  or the RMS value, autocorrelation function, or the Fourier spectrum of the surface profile. These values may be obtained by integrated measurements of surface sections, or from knowledge of the three dimensions topography of the surface.

Instruments designed to reconstruct the three dimensional topography in fact explore the surface along linear sections, thereby obtaining an altitude profile from which the

25 desired parameters may be obtained using appropriate statistical criteria. A true three dimensional profile is obtained by scanning parallel sections. The various instruments designed to be used for this purpose are mainly 30 characterised by their sensitivity, their lateral resolution and their measurement range.

The measurement range which is of use for mechanical purposes usually extends from a fraction of a micrometer to some tens of micrometers.

35 In the case of the mechanical measurement range there are two main types of instrument (in addition to those instruments using the Moiré method or the projection of fringes or lines), whose sensitivity has a lower limit of a few micrometers, and these are the contact stylus instruments and optical profile measuring instruments.

Stylus instruments are very widely used.

40 Their vertical resolution is approximately ten Å, whereas their lateral resolution is a few micrometers.

45 Optical profile measuring instruments are devices of the non-contact type and may have a typical resolution of a fraction of a micrometer in vertical terms and a micrometer in lateral terms. There are also very sophisticated optical profile measuring instruments of the heterodyne and interferometer type which 50 have a much higher resolution such as the Sommargren, Wyant or Bennett instrument.

55 It is an object of this invention to provide an optical profile measuring instrument of simple and reliable construction and which 60 has good resolution and accuracy.

65 According to this invention there is provided an optical profile measuring instrument for the inspection of mechanical surfaces of specimens to be tested comprising means for producing a light beam which is concentrated

on a surface of a specimen to be tested and which is returned and deflected by a reflection separator to a detector, characterized in that the light beam is polychromatic, in that the beam which is incident on the surface is dispersed longitudinally by a longitudinal dispersion device, and in that the returned beam is dispersed by an angular dispersion device, and in that the detector is arranged to detect the angularly dispersed beam.

The instrument of this invention is of the non-contact type and is designed to operate in sequence with an operating machine and can supply altitude data in practice in real time.

70 80 Its vertical resolution is close to that obtained by the interferometer method. Its lateral sensitivity depends on the dimension the spot focussed on the surface under test and may be approximately one micrometer.

85 The detector may be formed from an array or a matrix of photodiodes which are associated with a detection circuit.

In use the components of the instrument may be static with the exception of the specimen which is provided with relative movement.

90 Advantageously, the means for producing the light beam includes a slit and the detector is a photodiode matrix arranged for three dimensional detection.

95 According to another aspect of this invention there is provided an optical profile measuring instrument for inspection of mechanical surfaces of specimens to be tested, said instrument comprising means for producing a polychromatic light beam, means for concentrating the beam on the surface of a specimen to be tested, means for longitudinally dispersing the beam before the beam is incident on

100 said surface, a detector, means for reflecting light returned from said surface onto the detector, and means for subjecting the returned light to angular dispersion before the returned light is incident on the detector.

105 110 This invention will now be described in more detail, by way of example, with reference to the drawings in which:

115 Figure 1 is a diagram of a conventional optical profile measuring instrument; and

120 115 Figure 2 is a diagram of an optical profile measuring instrument embodying this invention.

The operating principle of the conventional instrument is shown in Fig. 1. The reference 120 1 indicates a collimated monochromatic light source producing a parallel beam which is incident on and passes through a separator 3 in order to reach a first lens 5. The first lens 5 concentrates the beam on the surface of the

125 specimen to be tested being movable in the direction of the arrow. The reflected light again passes through the lens 5 and is deflected by the separator 7 to a second lens 9 which concentrates it on a diaphragm 11,

130 in front of a detector 13.

The detector receives the maximum signal when the surface of the specimen is located in the focus of the lens 5. This concept forms the basis of a conventional instrument, in

5 which the lens 1 oscillates longitudinally and the signal is detected in phase with the oscillation.

A similar construction is used in the instrument embodying the invention, together with

10 wavelength coding of a sequence of longitudinal foci, as shown in the drawings, resulting from the use of polychromatic, rather than monochromatic light, whilst the component elements are all static with the exception of

15 the specimen to be tested. In this case a plurality of foci are axially formed, each of which is related to a respective wavelength. The corresponding signals are then laterally dispersed using the characteristics of the various wavelengths prior to reception by a detector constituted by an array of photodiodes. the photodiodes are scanned sequentially and, the maximum value of the resulting signal corresponds to the position of the surface of the

20 specimen being tested.

25 Fig. 2 shows an operational diagram of the instrument embodying the invention. Light from a polychromatic light source 21 is converted by an achromatic collimator 23 into a

30 collimated beam having parallel rays. The collimated polychromatic light beam passes through a separator 25 and a longitudinal dispersion and focussing device 27. Consequently, there is formed around the surface to

35 be analysed of a specimen 29 a series of foci  $F_1-F_n$  each relating to a respective wavelength and therefore to a respective wavelength of monochromatic light. The light reflected from the surface passes through the dispersion and

40 focussing device 27 and is deflected by the separator 25 to an angular dispersion and focussing device 31. The angularly dispersed light is focused along an array of photodiodes 33 connected to the electronic circuit 35. The

45 source 21 is advantageously defined by a diaphragm 37 having a slit orthogonal to the direction in which the dispersion takes place and therefore optically orthogonal to the array of photodiodes 33.

50 The measurement range is controlled by the longitudinal dispersion and by the focusing characteristics. The angular dispersion and the characteristics of the second focusing device 31 should be adapted to the detector used.

55 The sensitivity and the lateral resolution depend on the same parameters.

60 The longitudinal dispersion and focusing device 27, designed to provide the longitudinal dispersion and focusing effect, may comprise two separate components: a simple lens 27A acting as the dispersion device and a microscope lens 27B. Alternatively the dispersion component may be incorporated in the collimator lens 23 or in the focusing lens by

65 means of a suitable optical unit.

The angular dispersion and focusing device 31 may also comprise two components. The first may be a prism, but may also be a grating. The second may be a corrected lens.

70 The light source 21 may be a white light lamp with a condenser and a slit. The slit simplifies alignment and extends the use of the device to three dimensional topography on an entire section with a matrix of photodiodes

75 as the detector.

Suitable data processing software should be provided for use with the instrument.

The use of the signals of the various photodiodes is designed for the differential measurement of very small displacements about a given position, the latter being associated with the position of a particular distribution function. The position may be the centre line of the function or the position of a peak.

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85 CLAIMS

1. An optical profile measuring instrument for the inspection of mechanical surfaces of specimens to be tested comprising means for producing a light beam which is concentrated on a surface of a specimen to be tested and which is returned and deflected by a reflection separator to a detector, characterized in that the light beam is polychromatic, in that the beam which is incident on the surface is dispersed longitudinally by a longitudinal dispersion device, and in that the returned beam is dispersed by an angular dispersion device and in that the detector is arranged to detect the angularly dispersed beam.
2. An optical profile measuring instrument as claimed in claim 1 characterized in that the detector is formed by an array or a matrix of photodiodes which are associated with a detection circuit.
3. An optical profile measuring instrument as claimed in claim 1 or claim 2, characterized in that, in use, the components of the instrument are static with the exception of the specimen which is provided with relative movement.
4. An optical profile measuring instrument as claimed in any one of the preceding claims, characterized in that the means for producing the light beam include a slit and in that the detector is a photodiode matrix arranged for three dimensional detection.
5. An optical profile measuring instrument for inspection of mechanical surfaces of specimens to be tested, said instrument comprising means for producing a polychromatic light beam, means for concentrating the beam on the surface of a specimen to be tested, means for longitudinally dispersing the beam before the beam is incident on said surface, a detector, means for reflecting light returned from said surface onto the detector, and means for subjecting the returned light to angular dispersion before the returned light is incident on the detector.

6. An optical profile measuring instrument substantially as hereinbefore described with reference to and as shown in Fig. 2 of the accompanying Drawings.

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